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THE NASAL ADMINISTRATION OF NITROUS OXIDE

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The Nasal Administration of Nitrous Oxide Gas.

By FRANK COLEMAN, L.R.C.P., M.R.C.S., L.D.S.

Nitrous oxide gas may be administered through the nose in various ways and by means of various forms of apparatus. The method has been prominently brought before the profession during the last ten years, and its limits of usefulness have by no means yet been reached.

The earliest attempts at nasal administration of anæsthetics dates back to 1859, when Dr. Fauré, of Paris (*Gazette des Hôpitaux*, July 7, 1859), described a method of inhalation of chloroform through one nostril. Dr. Fauré employed his method in all cases in which chloroform was to be given, and designed that the mouth should be closed, so that one nostril should receive the tube which conveyed the chloroform vapour and the other nostril should remain patent to the external air.

A modification of Dr. Fauré's method appeared two years later by Dr. Sansom (*Medical Times and Gazette*, May 25, 1861), who advised that anæsthesia should first be procured in the usual way, and subsequently maintained through a single tube passed into the nose, the unengaged nostril forming a useful valve for promoting or retarding the dilution of the chloroform.

In England Dr. Richardson (later Sir Benjamin Ward Richardson) was the first to employ this method of anæsthetization. His apparatus consisted of a single tube connected with a chloroform inhaler and was first utilized in a case in which Sir (then Mr.) Spencer Wells

removed half the lower jaw. Dr. Richardson's apparatus was subsequently modified by Mr. Alfred Coleman (*Lancet*, January 11, 1862), who introduced two short silver tubes which were passed into each nostril, but no great advantage was obtained until an air-syringe was connected with the inhaler, by means of which the mixture of air and chloroform vapour was forced into the air passages.

These forms of apparatus have gradually led up to the one in present-day use — a modification of that described by Junker (*Medical Times and Gazette*, 1867, vol. ii.). A nasal catheter is substituted for the face-piece of Junker's chloroform apparatus, and the latter has been modified in various ways chiefly with the intention of preventing the serious risk of chloroform being ejected into the larynx, through the tilting of the chloroform bottle or wrongly adjusting the afferent and efferent tubes to the same. This contingency has been obviated, to a large extent, by Mr. Carter Braine who has directed attention to the shape of the vessel containing the chloroform, and by Dr. Hewitt, in his arrangement of its afferent and efferent tubing.

Mr. Clover (*Lancet*, February 15, 1868) was the first to introduce the nose-cap for administering anæsthesia of chloroform in operations in which the mouth is kept open. The cap was furnished with inspiratory and expiratory valves and was connected by a tube with a bag which contained air mixed with four per cent. of chloroform vapour.

Clover was likewise the first to administer this drug in definite proportions. The bag was charged by a bellows of a definite capacity (1,000 cubic inches), and a known quantity of chloroform (32 minims) was supplied to each bellowsful of air.

Although by this method anæsthesia can be maintained indefinitely with the mouth kept open, it is one in which grave risks are incurred and quite unwarrantable in Dental Surgery.

In 1898 two methods were introduced by which nitrous oxide could be administered through the nose and anæsthesia maintained while operations on the mouth were being carried out, and these methods were brought forward before the Society of Anæsthetists within a month of each other.

In March, 1898, Mr. Alfred Coleman [1] read a paper before the Society of Anæsthetists *On a Method of Administering Anæsthetics through the Nose*, and showed an apparatus which he had devised for the purpose. This consisted of a nose-piece connected by a flattened tube, adapted to fit accurately over the forehead to an ordinary gas-bag, an intervening two-way stopcock containing a valve which opened towards the nose, and an air-padded face-piece which was large enough to cover both the nose-piece and the mouth.

With this apparatus Mr. H. J. Paterson undertook fifteen dental cases and secured an average anæsthesia of two and a half minutes, all of which, he stated, could probably have been continued for a longer period if required.

Mr. Alfred Coleman's apparatus was originally designed for administering ether through the nose, the ether-chamber being interposed between the gas-bag and the gas cylinders. As a preliminary, however, to the administration of the ether, nitrous oxide was utilized, and this by itself was found so capable of maintaining anæsthesia that future experiments were conducted with the ether-chamber left out of the circuit.

Mr. H. J. Paterson introduced lateral tubes to the nose-piece in place of the single central tube, and made other improvements which brought the apparatus from an experimental into a practical form.

In the following month, Mr. Harvey Hilliard [2] explained a method of prolonging nitrous oxide anæsthesia

[1] *Transactions of the Society of Anæsthetists*, March 17, 1898.
[2] *Ibid.*, April 21, 1898.

in dental practice by means of a tube passed into the nose, after the patient is rendered unconscious by anæsthesia induced in the ordinary way, and leading the supply of gas through the nasal tube. I have had no experience of this method and have seen but little of its application in practice.

More recently, the late Mr. R. P. Lennox of Cambridge, devised a simple nasal inhaler for the continuous administration of nitrous oxide. The nose-piece consists of a metal plate bent up to fit the base of the nose, and two metal tubes which convey the gas are let into this plate in such a way that the apertures are opposite the anterior nares. The nose-piece is connected with the stopcock, gas-bag and cylinders in the ordinary way, but these parts are somewhat modified; a small bag is used and the gas is made to traverse a spiral copper tube immersed in a reservoir of hot water before it reaches the bag, as suggested by Mr. Coxon. One of the cylinders of gas leads to the ordinary gas apparatus with which the administration is commenced.

The nose-piece is slightly pliable, and is thus capable of being adapted to noses of various shapes; further, the soft tissues around the nostrils form an efficient pad for the exclusion of air when sufficient traction is exerted on the nose-piece by means of the elastic loop which goes round the patient's head. I have used this inhaler on several occasions, but have found that the metal plate does not remain well up against the nostrils; it tends to fall away on one side or the other and allows the gas to escape. This defect might be remedied to some extent by the use of a stouter elastic band. However, I must acknowledge my indebtedness to Lennox's inhaler since it has been the means of suggesting to me several points that are embodied in the apparatus which I shall presently describe.

Last year Mr. Bellamy Gardner [1] utilized the nasal

[1] *Transactions of the Odontological Society*, January, 1907.

method for administering nitrous oxide with definite quantities of oxygen. His apparatus consisted of Paterson's nose-piece with tubes leading to Hewitt's gas-and-oxygen mixing chamber, which was fitted to a double rubber bag connected to the cylinders, and a modified stopcock between the nose-piece and the mixing chamber.

The rubber bag in question is a modification of that devised by Dr. Levy for employment with Hewitt's gas-and-oxygen apparatus, and consists of a small bag for the oxygen placed within a larger bag for the nitrous oxide, an arrangement which renders the pressure of the contained gases always identical. The stopcock which is interposed between the nose-piece and the mixing chamber contains a removable and reversible chimney, and according to the position in which the chimney is set, the apparatus may be used with a face-piece for an ordinary gas-and-oxygen administration, or with a nose-piece for cases in which it is desired to maintain anæsthesia with these gases.

An apparatus which can be employed for two purposes has undoubtedly other advantages than that of portability, and Mr. Bellamy Gardner's apparatus seems well suited for an ordinary gas-and-oxygen administration, but whether the full advantages derived by giving definite mixtures of gas-and-oxygen through the nose can be obtained with it in presence of the many adventitious factors associated with nasal administration must appear doubtful.

A discrepancy in the amount of oxygen which the patient is receiving by the mouth will always remain a disturbing factor to any carefully regulated percentage of gases admitted through the stopcock, and such regulation must necessitate a rather more complicated apparatus. Mr. Bellamy Gardner himself remarks that the administrator's right hand is permanently employed in holding the nose-piece in position, and his left hand is intermittently engaged in regulating the percentage of oxygen.

Other slight modifications of inhalers have been suggested and carried out, such as the use of a unilateral tube, &c.

In my first uses of the ordinary Paterson's nose-piece I soon became aware that if the operator displaced it upwards, while extracting upper front teeth, the gas was cut off for the time being owing to the two apertures which admitted the gas into the inhaler not being in line with the anterior nares; whereas it was obvious that if these apertures were made to correspond to the nostrils, as in Lennox's inhaler, the more the operator pushed the nose-piece upwards the better the apertures would approximate and correspond to one another.

I had previously considered the desirability of doing away with pads of all kinds and of having an apparatus which was both cleanly and simple. The fact that Lennox's inhaler required no pad was evidence that pads could be dispensed with, even perhaps better in a nose-piece which fits over the entire organ than in a nose-piece which is applied only to one part of the nose. Again, we know that closer adaptation can be obtained between a resistant and a non-resistant or yielding substance than between two non-resistant bodies, as is proved in many forms of engineering work.

Some means of retaining the inhaler in position other than by elastic bands also appeared desirable, and I was led to try whether the tubing which conveyed the gas could not be made to serve this end. After experimenting with both metal tubing and rubber tubing and various forms of sliding clamps for adjusting purposes, some approximation to the ideal, I think, has been obtained.

A fixed apparatus necessarily implied the use of a stopcock capable of admitting air to the inhaler, as the inhaler could not be easily removed and replaced for this purpose; further, as the stopcock would probably be in requisition more or less throughout the administration, it would be necessary to devise one in which the movements were simple, easily controlled and conveniently

applied. The apparatus was completed by means of a mouth-cover, the remaining parts being those of an ordinary gas apparatus.

The metal mouth-cover has a thick rounded rim, where it comes in contact with the soft tissues of the face, and contains a removable expiratory valve protected by two cross pieces of metal.

At one time I had hoped that by introducing an inspiratory valve over the air-aperture it might be possible to devise a stopcock which would allow of definite proportions of gas and air being admitted to the inhaler without adding complication to its movements. Various forms were tried with this object in view, but all failed on account of the "load of gas" on the proximal side of the valve interfering with its proper working.

Since writing the above, I have been able to carry principle into practice and have recently designed a stopcock which allows of definite quantities of gas and air being admitted to the inhaler. The principle of this stopcock depends upon the use of a single valve for controlling both the gas and air entry to its interior, and the aperture which admits them is divided in such a way that the periphery serves for the entrance of air and the central portion for the entrance of gas. By this arrangement, air can be admitted to the inhaler to the desired extent and under any pressure of gas; the inspiratory valve is closed only during expiration. This principle involves two other advantages of no mean importance besides that of "graduating the dose," viz., the inspiratory valve is put into action and so tested with air alone before nitrous oxide is inhaled; further, the patient in respiring through the valves experiences but little discomfort when the anæsthetist substitutes nitrous oxide for air.

Attempts were likewise made to reduce the weight of the apparatus and so lessen the strain on the patient's nasal organ, by suspending the stopcock with a chain to some convenient part of the dental chair; a metal

hook fixed on to the stopcock was also introduced for a similar purpose, but both these devices favoured the slipping of the patient's head out of the loop formed by the nose-piece, conveying tubes and clamp, when any movement on his part occurred, and as the pressure caused by the nasal cap was not of grave consequence, producing at the most but a momentary redness, further attempts to overcome this difficulty were abandoned.

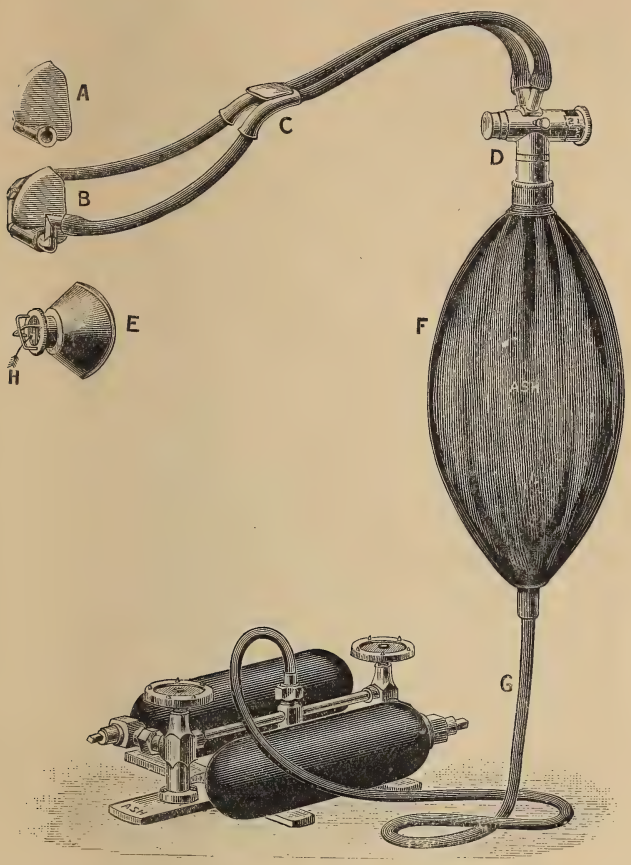
If at the commencement of the administration the stopcock is supported in the hand and only released as the patient loses consciousness, he will be spared any inconvenience which arises from the weight of the gas-bag and tubing.

The suggestions already described have been carried out in the apparatus here illustrated which I recently designed. It consists of a nose-piece B, conveying tubes and adjusting clamp C, and a two-way stopcock D; the remaining parts are those of an ordinary gas apparatus with the addition of a mouth-cover E, which is fitted with an expiratory valve H. The nose-piece, conveying tubes, stopcock, and mouth-cover have been modified and simplified as follows :—

(1) The nose-piece, which is carefully adapted to the shape of the nose, is fitted with two lateral tubes which open under the nostrils and thus convey the gas directly to the nose. The snug fit of the nose-piece and the position of the openings render an india-rubber pad unnecessary.

(2) The conveying tubes between the nose-piece and the stopcock are held in position when they are adjusted on the head by means of the sliding clamp C, and the clamp is kept where it is set by the weight of the apparatus. The short metal pipes with double bend on each side of the nose-piece are so arranged that the conveying tubes exert their force in bringing the nose-piece evenly up against the face and over the nose.

(3) The stopcock consists of an outer and an inner drum. The inner drum, which is graduated, can be



NASAL INHALER CONNECTED UP WITH NOSE-PIECE AND MOUTH-COVER SHOWN SEPARATELY.

A—Nose-piece disconnected.
B—Nose-piece secured to the metal connections and india-rubber conveying pipes.
C—Sliding clamp.
D—Stopcock.
E—Mouth-cover.
F—Cattlin's bag.
G—India-rubber tubing which leads to the union on the gas cylinder.
H—Expiratory valve.

projected beyond either end of the outer drum and, according to the position in which it is set, gas, air, or a mixture of the two can be admitted to the inhaler. The movement of the inner drum controls the size of the apertures which admit gas and air; both apertures are similar in shape, and the former is fitted with an inspiratory valve which prevents re-breathing into the gas-bag.

(4) The mouth-cover is made entirely of metal, except the expiratory valve, which is removable. It has been carefully adapted to the shape which the mouth assumes when partly open, as with a mouth-prop *in situ*, and is made in two sizes.

Briefly stated, the advantages of this modified nasal inhaler are as follows:—

(1) It is self-retaining and affords freedom to the anæsthetist, who is thus at liberty to insert a gag or to assist the operator in other ways.

(2) The metal nose-piece and mouth-cover are easily removed and cleansed, and the use of rubber pads is avoided.

(3) The stopcock allows of the admission of mixtures of gas and air to the inhaler, and its movements are simpler than the ordinary tap-form of stopcock.

Nitrous oxide is the most suitable anæsthetic for the majority of such short operations as the extraction of teeth, since it is almost entirely free from danger and allows of a return to consciousness with but little discomfort and few after-effects. The absence of after-effects is not entirely dependent upon the briefness of inhalation: they are but slight and transient when anæsthesia is maintained for five minutes or more and three or four times the usual amount of nitrous oxide is inhaled. No doubt a more important factor in the absence of after-effects is the unstable combination which nitrous oxide forms with the hæmoglobin of the red blood-cells and its stimulating action on the circulation. A safe and rapidly-acting anæsthetic is the desideratum for such cases, and this we have in nitrous oxide.

The operations on the mouth for which nasal administration is suitable are chiefly those connected with the teeth or the surrounding parts, *e.g.*, multiple or difficult extractions, the removal of pulps, the preparation of roots for crowns, the opening of antra or cysts and the removal of small innocent growths, &c. For multiple extractions which present no special difficulties, but only the element of time for their successful performance, this method has many advantages.

Before commencing to anæsthetize a patient it is necessary to see that both the apparatus and the drugs to be used are efficient, and that the needful accessories are also at hand, viz.: a mouth-gag, a wooden mouth-opener, some props, a mouth spoon, some sponge-holders and sponges, a tongue forceps, a hypodermic syringe, a supply of strychnine, adrenalin and amyl nitrite; also a tracheotomy case containing a tracheotomy tube, a scalpel, small retractors, dissecting and artery forceps, blunt hooks, and a two-bladed tracheotomy dilator. It is hardly possible to discuss fully the merits of the various kinds of instruments mentioned, but a few points may be briefly referred to.

Two mouth-gags are a convenience and one of these should be Ackland's pattern, with the jaws closing side by side, which form a wedge of only half the thickness of the old style of gag, to facilitate introduction in cases of closure of the jaws, whether from trismus or the slipping of a prop during the administration.

Hewitt's mouth-props with lead pads are quite serviceable, and with the smaller sizes now made will be found convenient for patients of all ages. Those with rubber pads are somewhat troublesome to clean between consecutive administrations, as in hospital work. A strong boxwood mouth-opener is useful for emergencies, but will not often be required if an Ackland's gag be at hand.

Sponge-holders should have a firm sliding catch, tongue forceps should have grooved blades and ratchet handles and the hypodermic syringe may be of glass or metal

with a well-fitting piston. Efficiency and simplicity are the attributes of good surgical instruments, which implies ease of cleaning and keeping aseptic.

For hospital work, the Barth triple-union, with stand for three cylinders, forms a useful equipment, two of the cylinders being connected by a Y-shaped union with the nasal apparatus. For a portable apparatus, two fifty-gallon cylinders united by a Y-shaped union is the most convenient size. In either case, one reserve cylinder, fully charged, should always be at hand.

Attention should next be directed to the patient's comfort, which should as far as possible be adapted to the needs of the operator and the anæsthetist. At least three hours should elapse between the patient's last meal and the operation, and the meal should be moderate in amount and plain, fats and other rich articles of diet being avoided to the fullest possible extent. It is advantageous for the bowels to be emptied on the morning on which the anæsthetic is to be given, or on the previous day, if the patient is irregular in this function and requires a purgative, and for the bladder to be emptied shortly before the administration commences.

The anæsthetist should make a mental note of the patient's condition before he undertakes the administration—as to whether the patient appears active, healthy and robust, or pale, weak and anæmic. An examination of the heart and lungs must be made in cases in which patients are pale, weak and anæmic, but preferably in all cases.

If the administrator is the patient's usual medical attendant he will be already familiar with his health, vigour and temperament.

Young adults and middle-aged people, especially women, are good subjects for nasal administration of nitrous oxide.

Patients suffering from chronic bronchitis or advanced phthisis must be carefully watched, and undue cyanosis must be strictly avoided. Sufferers from valvular disease

of the heart, where the lesions are uncompensated, must also be carefully watched.

The colour of the face, the character of the pulse and respiration, and the presence of signs of back-pressure are the chief factors in determining how far compensation is maintained.

Patients who are the subjects of advanced arterial degeneration (atheroma) with its sequences should not be submitted to this form of anæsthesia, and would be better advised to undergo anæsthesia with gas and oxygen on one or more occasions, rather than submit to one prolonged anæsthesia by the nasal method.

It is generally stated that nitrous oxide may be safely administered up to within the last month of pregnancy, and the same rule holds good with the nasal method, provided coughing and straining are avoided as far as possible. If the patient be subject to shortness of breath, palpitation, fainting fits, &c., or there be otherwise any doubt as to his health, his usual medical attendant should, if possible, be previously seen or communicated with and advice obtained as to the desirability of the patient taking an anæsthetic or undergoing an operation. Patients at the extremes of age are not good subjects for this form of anæsthetization, but fortunately in these cases a prolonged anæsthesia is not often required for dental work. Alcoholics are bad subjects for any form of nitrous oxide administration or the administration of any other anæsthetic, as also are persons who are addicted to any drug habit, such as cocaine or morphia, or who indulge to excess in tobacco smoking.

The anæsthetist should enquire of the operator what duration of anæthesia is likely to be required, make himself acquainted with what the operator has to do, which jaw he is going to work on and where a gag is likely to be wanted. He should also anticipate any assistance which the dentist is likely to need, such as altering the position of the patient's head, increasing the amount of space for working in, or introducing a mouth-

gag, &c. At the same time the dentist should, as far as possible, keep to an orderly method of working; he should remove lower teeth before upper, back teeth before front teeth, and confine his attention to one side of the mouth before proceeding to the other. In the event of a tooth being broken under extraction he should see that every portion is removed from the mouth before he attempts to extract other teeth; he may, from time to time, require to sponge out the patient's mouth and throat owing to the anæsthetist's attention being frequently too fully occupied with other matters to deal with this feature of the operation. While extracting lower back teeth the operator must be careful to avoid pressing back the root of the tongue, or depressing the jaw, either of which will be harmful to an anæsthetized patient. All tight clothing, such as corsets, belts, and collars, should be loosened, so that the chest, abdomen, and throat may be in no way impeded during respiratory, or possibly struggling, movements. The patient should sit well back in the chair, with the head and neck in a line with the body. The posture should be one of muscular relaxation and free from restraint; there should be no toe-piece or other obstacle about the operating chair which may cramp the body and allow of leverage should struggling movements ensue. The position must be that which favours a satisfactory anæsthesia, and such as can, if necessary, be altered during unconsciousness to meet the requirements of the operator. It is desirable to fasten an apron or a towel round the patient's neck to prevent the clothing being soiled. The mouth should be opened and a glance taken in it to ascertain its contents. Any artificial teeth should be removed, and the presence of artificial crowns, loose teeth, loose roots, or other impediments to the insertion of a prop or gag should be noted. Before inserting a prop it is advisable, except perhaps in the case of nervous patients, to explain briefly to the patient the advantages of the particular method about to be

employed, and to let him see the apparatus. An intelligent patient will then immediately grasp what is required of him, and be a help rather than a hindrance in the carrying out of the administration.

I feel convinced that the complicated instructions which are frequently given to a patient about breathing are a mistake, and only tend to nervousness and confusion. There is no advantage in the deep inspirations which the patient is so frequently impressed to take ; they will be taken involuntarily in a more agreeable manner as consciousness is gradually lost. It is only necessary to tell the patient that you wish him to draw in the gas through the nose, to breathe it out through the mouth, and to explain how this is done by temporarily placing the mouth-cover in position. If the expiratory valve of the mouth-cover is working well while the patient takes two or three breaths of air through the nose, you can be satisfied that there is no obstruction to nasal respiration, and the patient will be convinced that he is able to carry out your instructions.

Children, perhaps, require managing a little differently from adults, but in the case of children it is even more important not to burden them with unnecessary instructions. It is often best to wait and see for yourself the type of respiration the child presents, and only to give instructions if necessary; to err rather in encouraging than in discouraging him.

So much depends upon the induction of nitrous oxide, in obtaining a satisfactory anæsthesia, that all these small points deserve attention.

The patient's friends should be requested to wait in an adjoining room, and only if they expressly desire should they be allowed to remain in the same room, away from the patient. When this permission is granted, they should be previously warned that the patient while under the influence of nitrous oxide may present an unpleasant appearance or perhaps struggle and become noisy.

The mouth-prop should, where possible, be fixed on

the side of the mouth opposite to that on which the operation is to take place, and if possible behind the premolar region; in any case, it should be fixed no further forward than the canine teeth. The mouth should be well opened, but not to its utmost, as this would put the masseters on the stretch, render the cheek rigid, and hinder the operator's movements. Naturally, when the prop can be so placed as to obviate the subsequent use of a mouth-gag, this is desirable, both from the point of view of economizing time during anæsthesia, and of allowing the anæsthetist more freedom for steadying the patient's head.

The patient should next be requested to close the lips as far as possible; this induces closure of the jaws and renders the position of the prop more secure. If the patient has difficulty in opening the mouth owing to inflammatory œdema of the masseteric and pterygoid regions (trismus), the teeth may be separated by a small prop, and sufficient space obtained for the subsequent introduction of a gag during anæsthesia; but if the amount of separation is too small to admit of this, the mouth can, if necessary, be opened during anæsthesia with an Ackland's gag, assisted by the use of a wooden wedge on the opposite side. Care should be taken to employ the wedge on strong back teeth.

Everything being in readiness, the administrator usually stands to the left and somewhat behind the dental chair. This allows of better control of the patient's head during the anæsthesia. The cylinders of nitrous oxide should be in a position easily controlled by the anæsthetist's right foot and out of the way of the operator.

A small quantity of nitrous oxide is passed through the apparatus to free it from air, or perhaps from the remains of a previous administration. The stopcock is now shut off from the gas-bag; the bag is quietly filled to half or two-thirds of its capacity with nitrous oxide gas, and the screw valve of the cylinder is lightly turned off. The nose-piece is carefully placed over the patient's nose, and

the tubing is adjusted to the head by means of the sliding clamp; the clamp is kept where it is set by the weight of the apparatus. After the patient has taken two or three inspirations of air through the nose-piece, and has become accustomed to his surroundings, the stopcock is closed and nitrous oxide is admitted to the inhaler. The patient now inhales nitrous oxide through the nose, and exhales through the mouth (naso-oral breathing). As long as the patient continues to breathe in this manner, there is no need to place the mouth-cover in position; patients feel less burdened without it.

The bag requires to be replenished from time to time with fresh supplies of gas, by turning on the foot-key, and to be kept at a constant pressure of one half to two-thirds of its capacity. As far as possible, the ingress of gas should be opened during inspiration. If the bag be kept over-distended, its elasticity becomes weakened, and it is less capable of emptying itself. With the idea of increasing the pressure of the gas, I at one time made use of a thick red rubber bag. This, however, I subsequently found to be less elastic than the ordinary black rubber bag, and of little, if any, advantage. The pressure of gas may be temporarily increased by squeezing the bag between one's knee and the chair; but if it is not allowed to become over-distended, and gas is admitted, as far as possible, during inspiration, there will rarely be any need for any of these subsidiary measures. Evidence of excitement from oral breathing, or entrance of air around the inhaler, must be overcome by increasing the pressure in the bag and placing the mouth-cover in position.

The induction stage of nitrous oxide is but little prolonged by the use of the nasal method. Curiously enough, some patients appear to become unconscious even more rapidly by the nasal than by the ordinary method of inhalation. As a rule, consciousness is lost in from half a minute upwards, according to the mode of administration; thus, if the mouth-cover be applied throughout the inhalation, the period will be practically of the same

duration as in an ordinary gas administration. During this period the patient first experiences the sweetish but not unpleasant taste of nitrous oxide, and soon becomes aware of a feeling of dizziness and drowsiness, accompanied with pulsative throbbing, chiefly in the head. Voices or noises heard assume a peculiar staccato rhythm; they almost become monotonous, and often apparently last throughout the anæsthesia.

Respirations become deeper, quicker, and regular as consciousness is gradually lost, and the pulse, if previously quickened through excitement, becomes slower and fuller, although slightly more accelerated than normal.

In less than half a minute, impressions conveyed from the special sense organs become dulled and altered in character; thus, numbness is frequently felt in the limbs, tinnitus in the ears, &c., hearing being the last to remain in obeisance and the earliest to return during recovery from anæsthesia. After normal consciousness is lost, a period follows in which psychical disturbances ensue. The patient during this time may remain perfectly quiet, unless these disturbances be of an unpleasant nature, in which case he may react to them by struggling and shouting, or by less violent rhythmical movements of his feet and hands. As a rule, the struggling, &c., indicates faulty administration, the patient having received too much air, either from a badly fitting apparatus or one improperly applied. The pupils at this stage usually begin to dilate, the conjunctival reflex still persists, the colour, which has perhaps become a little dusky or livid, now becomes more so, especially in patients of a vigorous and plethoric type. After another breath or two, the conjunctival reflex will be lost or react but sluggishly. This can be determined by lightly touching the ocular conjunctiva, which will be followed by closure of the lids if the reflex persists.

At this stage, there is frequently a change from "naso-oral" breathing to "to and fro" nasal breathing,

which is evidenced by escape of the expired gases around the nose-piece, especially at the inner angle of the eye. I have noticed this so frequently that it has become to me a useful sign of unconsciousness and approaching anæsthesia; even the firm application of the mouth-cover throughout the inhalation has little, if any, effect in modifying this phase.

A faintly audible inspiratory roughness, followed by a short and more forcible expiration, which produces a "catch" in the breathing, perhaps accompanied with fine twitching movements of the eyelids and slight jactitation, now takes the place of the previously quiet rhythm, or the breathing may assume a soft, regular, snoring character.

When the operator is commencing on the lower jaw, there is no need to go beyond, or even quite to reach, this stage; anæsthesia will tend to deepen a little, owing to the operator's fingers in the mouth obstructing the air-way, and this will be further embarrassed if, at the same time, the tongue be pushed back or the jaw depressed.

In the case of operations upon the upper jaw, however, slightly deeper anæsthesia may be produced, but even here it is unnecessary to carry the inhalation to quite the same degree as in an ordinary gas anæsthesia, where the result, to some extent, depends upon the initial dose. In this respect, the inhalation period, with almost entire absence of cyanosis and stertor, closely resembles that of nitrous oxide and oxygen.

If the inhalation is continued beyond the above stage, both inspiration and expiration become altered in character and rhythm; inspiration has the character of a series of short, jerky, muscular attempts to create a vacuum and so to fill the lungs, and expiration manifests itself as a spasmodic, irregular recoil of the chest wall, both being accompanied by the peculiar and characteristic "snorting" sound known as stertor, which is due to obstruction in the upper respiratory passage, probably from irregular and spasmodic contraction of the elevators of the larynx, which raise it towards the epiglottis and

the base of the tongue. The pupils become further dilated, and the eyelids, slightly separated, display the subjacent globes, which are frequently turned upwards so that the upper lid must be raised to expose the pupil.

The patient is now fully under the influence of nitrous oxide, and further administration will result in jactitation, cyanosis, and convulsive movements of the body.

The induction stage of nitrous oxide is sometimes described in degrees of narcosis, but it is doubtful whether such is of much value, one stage following upon another with little or no arbitrary demarcation. For teaching purposes it is certainly undesirable to divide up the period of induction into degrees of narcosis ; signs and symptoms which usually occur at one stage may appear earlier or later, or be absent altogether ; and there is such a quick succession of changes that the beginner will be only baffled in endeavouring to group them.

It is better not to depend upon any one sign alone for basing anæsthesia, but to take the signs collectively, the type of respiration perhaps being the most reliable and evident guide as to the presence of anæsthesia.

Mr. Carter Braine[1] places great stress on the presence of twitchings in the orbicularis oculi, as an indication when anæsthesia has been carried sufficiently far, and although he refers to an ordinary gas administration his words may be usefully quoted in this connection :—

" It has been my custom for several years to stop the administration when I witness the presence of twitchings in the orbicularis oculi muscle at the internal canthus. I believe this is to be an invariable sign of anæsthesia with N_2O, and I cannot recall any case where, in the adult, it has not been present. In young children, the signs of anæsthesia follow one another so rapidly that I have not found this sign so reliable ; in their case, it is advisable to stop the administration directly any sign of muscular

[1] *British Dental Journal*, 1904, p. 719.

twitching is present, otherwise arching of the back may follow very rapidly, and the patient slip out of the chair on to the floor."

The operator should be warned when the patient is fully anæsthetized, and the mouth-cover, if employed, should now be removed.

During the inhalation period, it is rarely necessary to admit air through the stopcock, but when anæsthesia is once reached, it may be necessary, from time to time, to allow its entrance, avoiding, on the one hand, any undue cyanosis, while, on the other hand, a sufficient degree of anæsthesia must be maintained to abolish all painful sensations.

The patient will require to be guided through a somewhat narrow channel, which is being constantly influenced by the operator's manœuvres, the varying position of the patient's head, and adventitious factors, as the presence of blood in the mouth, &c. Fortunately, as the apparatus remains in position of itself, it requires but little attention, and the anæsthetist is free to steady the patient's head throughout the operation, and can, at the same time, employ his right hand for regulating the stopcock, inserting a gag, or altering the position of the patient's head to suit the needs of the operator. While the lower jaw is being operated on, the patient may tend to become somewhat cyanosed unless an occasional breath of air is admitted through the stopcock, or the latter is set in such a position that both gas and air may be admitted to the inhaler; but even this will not suffice if the operator is depressing the jaw, forcing back the root of the tongue, or unintentionally obstructing the air-passages in other ways. Under these circumstances the operation must cease and the patient must be allowed one or more clear breaths of air; only after cyanosis has passed off should the operation be continued.

When, however, upper teeth are being removed, it is generally necessary to shut off all air from the stopcock

and to increase the pressure of gas in the bag; at the same time, the patient's head requires to be steadied and any over-extension avoided. Should there be some slight return to consciousness, provided there be but little blood in the mouth, this may be sponged out, the mouth-cover replaced, and anæsthesia again procured. The nose-piece may require a little steadying while the operator is extracting upper incisor teeth, but will tend to spring back into position, as soon as the upper lip is released. On completion of the operation, the gas-bag is shut off from the stopcock, the sliding clamp is released, and the nose-piece is removed. On no account should anyone be allowed to remove the mouth-prop until the patient is fully conscious, and for preference, this part of the operation may be relegated to the patient himself. Although recovery is apparently slightly delayed as compared with an ordinary gas administration, this will be found not to be the case, if the recovery period of the latter be taken from the time the face-piece is removed. Considering the extra quantity of gas inhaled, recovery is remarkably rapid. The nose-piece can be disconnected from the tubing and sterilized, and the mouth-cover treated in a similar way after the removal of the expiratory valve. The gas-bag is now deflated, and if reversible, invaginated and cleansed.

As to after-effects, I cannot do better than quote Mr. MacCormac's[1] words, who gives an analysis of over 2,000 cases :—

"With regard to after-effects, they are practically *nil*. I have seen one or two cases of sickness, which proved, on questioning the patient, to have been due to the non-observance of the instructions given as to diet. I admit the possibility of clinical effects, such as dilation, headache, &c., but I can only say that so far as my experience goes I have yet to meet with such cases. I have questioned many patients, and examined a number, both

[1] Prolonged nitrous oxide anæsthesia.—*Ash's Quarterly Circular.*

immediately after the administration and after an interval of twenty-four hours, but a negative result has always been noted. They have, almost without exception, informed me that they felt quite well, and had experienced no discomfort, save that from the effects of the operation."

I think the above statement is perhaps a little too favourable ; headache, giddiness, faintness, nausea, and depression do undoubtedly follow this, as any other form of nitrous oxide administration. Certainly actual sickness is unusual, and the symptoms above mentioned, even if less transient, are certainly not increased proportionately to the amount of gas inhaled.

Statements made to the effect that the right side of the heart is liable to become dilated I do not believe to have been substantiated, and nasal inhalation has certainly not led to any permanent ill-effects, so far as I am aware.

It may be mentioned that there are two methods of induction made use of for administering nitrous oxide by the nose.

In one method, anæsthesia is attained in the ordinary way, and when complete the face-piece is removed, the head is steadied, and the nose-piece is applied.

In the other method, and the one I consider preferable, the nose-piece is applied from the commencement and the anæsthesia is conducted as I have described in detail above. This method has the advantage of the patient breathing from the commencement in the manner in which you wish him to continue throughout the administration, the mode of procedure is not suddenly changed, nor is the type of respiration altered, as is frequently the case under the first method.

Further, the first method necessitates a separate cylinder connected up with the ordinary gas apparatus, and involves some loss of time in changing from one apparatus to the other.

With regard to the contra-indications for nasal

administration of nitrous oxide, these, I believe, are very few, and may be almost said to be those of nitrous oxide in general, if the method be carried out in the proper way and undue cyanosis strictly avoided as militating against success.

I have used this method of nasal administration of nitrous oxide in some two or three hundred cases, and although this is but a small number compared with those recorded by Mr. John MacCormac and others who have worked at dental hospitals, still it has been enough to show me that there is rarely sufficient naso-pharyngeal obstruction, whether from adenoids, enlarged tonsils, hypertrophied turbinates, deviated septa, or other malformations, to contra-indicate this method.

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Nov. 16